THE PLANKTONOKRIT, A CENTRIFUGAL APPARATUS FOR THE VOLUMETRIC ESTIMATION OF THE FOOD-SUPPLY OF OYSTERS AND OTHER AQUATIC ANIMALS.

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To Dr. Victor Hensen of Kiel is due the credit of being the first to insist upon the importance of a quantitative determination of the primitive food supply of marine animals.

In place of the terms "Auftrieb" and "pelagische Mulder" (pelagic tow-stuff) introduced by Johannes Müller, and commonly employed by zoologists for nearly half a century, Hensen substituted the more comprehensive term, plankton,[1] to include all those free-swimming, or drifting organisms which make up the fauna and flora of the sea. As the result of the initiative taken by Hensen and based largely upon the investigation conducted in the North Sea and Atlantic Ocean under his leadership, there has been developed in less than a decade, one of the most important departments of biological science, to which Haeckel has applied the term planktology. Biologists interested in the practical solution of the difficulties met with in the preservation and propagation of the food supply of Man, as found in ocean and lake, bay and river, were quick to recognize the importance of planktonic studies; and the broad considerations of the physiologist, concerning the cycle of matter in the sea, have led to narrower, but, nevertheless, exceedingly important studies regarding the source, character and quantity of the food supply of edible fishes and mollusks.

It is each year becoming more evident to the fish and oyster culturist that he has before him a problem of very considerable complexity. He is awakening to the fact that it is not sufficient that he should be able to hatch out and liberate millions of young fish fry, or plant thousands of bushels of oyster spat, but that he must base his culture experiments upon a thorough knowledge of the conditions affecting the survival and growth of the planted forms.

To the very imperfect knowledge of fish culturists and oyster planters, may be largely attributed the fact that American oysters have for

[1] πλαγκτός, wandering, roaming.

years steadily diminished in abundance, notwithstanding the enormous quantity of plants spread out on the oyster grounds of our seaboards, as well as that the fisheries of the Great Lakes have, in several instances, grown steadily less profitable, notwithstanding that millions of young fry have been liberated annually; for unless the transplanted organism can find suitable and abundant food, the time and money spent in rearing it, up to the period of its planting, is practically wasted.

As the result of the planktonic studies of Hensen, aquiculture is taking on a new phase which promises to mark a period in its history as important as has been seen in the very rapid development of scientific agriculture, directly attributable to the teachings and methods of Sir John Bennett Lawes of Rothamstead, England.

A glance at recent literature is sufficient to show the marked contrast between modern planktonic investigation and the empirical methods hitherto employed in aquiculture.

Prof. H. B. Ward, in his paper on the "Food Supply of the Fish in the Great Lakes," and Prof. J. E. Reighard, in his reports on the "Biological Examination of Lake St. Clair," indicate very clearly that the practical failure of fish culturists to replenish the rapidly diminishing supply of white fish in the Great Lakes may be directly attributed to a lack of knowledge on the part of those conducting the fish hatcheries, of the conditions affecting the primitive food supply of these waters. In the work conducted under the direction of Prof. Reighard, we find the first recognition in this country of the prime importance of a knowledge of the protophytes of the plankton, constituting as they do the primitive food supply upon which are dependent all other forms of the plankton, as well as all higher aquatic organisms.

John P. Lotsy, in a study of the food of the oyster, clam and ribbed mussel, confirms what has long been known, that these mollusks feed almost entirely upon diatoms, and that a knowledge of the life conditions of these latter must furnish the basis of intelligent oyster culture.

In reviewing the literature pertaining to oysters and the oyster industries, frequent mention is found of the food of oysters and the importance of an abundant and regular supply of the same, but nowhere in the numerous reports of expensive investigations of oyster grounds, carried on by the various governments, do we find any systematic study of the protophytic plankton of the waters examined.

Other and much less important factors, such as depth and density of the water, the character of the bottom, etc., have received exhaustive attention and are to be found displayed in lengthy tables and expensive charts, whereas, the most important factor of all, the conditions of the oyster's food supply, are relegated to brief paragraphs and have as yet received practically no consideration at the hands of those who have sought to awaken interest in scientific oyster culture.

In this connection I may be allowed to quote briefly from Prof. Haeckel: "The unicellular plants (Protophyta) have very great importance in the physiology of the plankton and the cycle of matter in the sea, for they furnish by far the greater part of the primitive food (Urnährung). The inconceivable amount of food which the countless myriads of swimming marine animals consume daily is chiefly derived, directly or indirectly, from the planktonic flora, and in this the unicellular protophytes are of much greater importance than the multicellular metaphytes.

"Nevertheless, the natural history of these small plants has thus far been very much neglected. As yet, no botanist has attempted to consider the planktonic flora in general, and its relations to the planktonic fauna. Only that single class so rich in forms, the diatoms, has been thoroughly investigated and systematically worked up; as regards the other groups, not a single attempt at systemization has been made; and many simple forms of great importance have lately been recognized for the first time as unicellular plants."

James I. Peck, in a recent article on "The Sources of Marine Food," adds testimony to the importance of primary food supply, showing, in a number of instances, the steps in the series from the microscopic plants of the sea to the voracious bluefish or squeteague; the higher organisms in the series being dependent on the lower. How essential, then, to the planktologist is a knowledge of the conditions affecting the development of the protophyta, since these minute plants form the primitive organic food, determining the welfare of a long series of higher forms, ending with man himself. Means should be devised for establishing planktonic standards based upon the ascertained conditions existing in waters known to be prolific in higher forms of life.

Knowing that the oysters, clams and mussels depend practically upon diatomaceous food, and that certain bays, coves or estuaries are noted for the abundance and quality of their molluscan fauna,

let the average weight or bulk of diatoms for each cubic metre of such a region be determined and used as a standard of comparison, by means of which the culturist may estimate the value of neighboring waters.

Corporations such as are now rapidly securing control of the best oyster grounds of the coast, will not long be content to work under the rule-of-thumb methods of the unscientific oysterman. The experiments of laying out extensive oyster beds, or establishing fattening parks, are too costly to be undertaken on the basis of guess-work as to whether conditions are or are not favorable. The money invested in an oyster bed of one hundred thousand bushels is so great that a year's difference in the time required by the plants to reach marketable size means a very considerable profit or loss to the planters.

How to turn over the investment every two or three years, instead of every five years, is a question which affects very materially the dividends of a corporation engaged in oyster culture. In certain regions, the oysters grow rapidly in size, but do not become sufficiently fat to command the prices paid for oysters of a similar size from other beds. These thin oysters, for a few cents a bushel, can be transferred to parks or fattening ponds, where, by supplying them with waters rich in diatoms, they will become "primes" in the course of a few weeks.

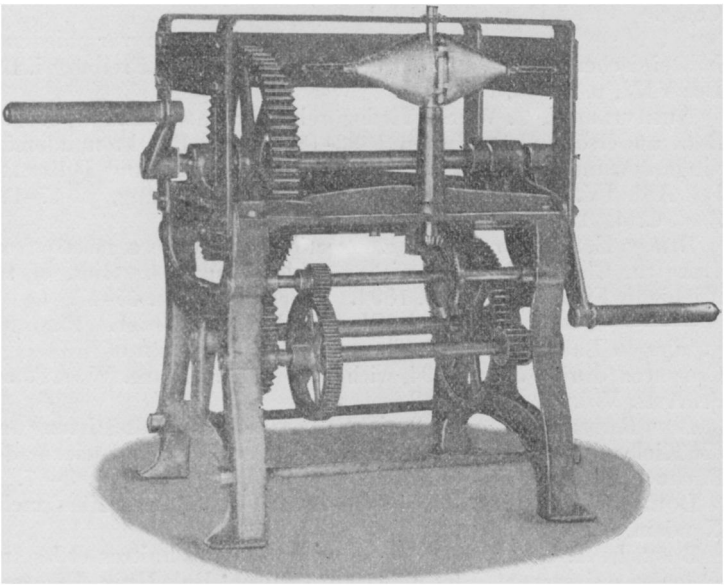
The advantage of such fattening is obvious, as is the fact that the time consumed in the process is a most important factor, the profit depending on whether the parks can be emptied of oysters and refilled every three weeks or every six weeks. To regulate conditions of this kind it is not enough to wait for results, to judge from day to day whether the oysters are fattening or not, and to judge the quality of the water of the park by the effects seen on the oysters. This method is unprofitable; it is either too slow, too uncertain or too wasteful. Variation in rainfall, in temperature, etc., will affect the relative number of food organisms in the water so materially that the best results can be secured only by a daily test of the supply.

Water rich in diatoms is too precious to be allowed to pass through the parks in quantities larger than necessary to bring the oysters to perfection in the shortest possible time. How now shall the ostreaculturist ascertain quickly and accurately the amount of plankton in the water of his parks and claires from day to day, or decide upon the best places for the location of new beds as regards food supply?

The methods adopted by Hensen and his followers in estimating the plankton content of any given area of water, are tedious in the extreme, and hold the same relation to practical fish and oyster culture as do the old fashioned methods of counting blood corpuscles and milk globules to the modern use of the hematocrit for the quantitative estimation of blood corpuscles; or of the various centrifugal machines and the Babcock system for the determination of the fat contents of milk. To the use of the pelagic tow-net we are indebted for practically all our present knowledge of minute aquatic organisms, and in so far as concerns the enumeration of the species constituting the plankton of any given region, no improvement can be suggested over the methods now employed. Prof. Haeckel has, however, very clearly pointed out the difficulties connected with Hensen's method of counting the individuals obtained in each haul of the net and that such counting "possesses only an approximate and relative value," and further, that "the only thorough method of determining the yield in planktology is the determination of the useful substance according to mass and weight, and subsequent chemical analysis." Without undervaluing in any way the counting methods at present employed by planktologists, I desire here to call attention to an apparatus which I have devised and by means of which one may make a large number of plankton estimations in a single day, in each case determining the volume and weight, rather than the number of individuals. By means of this apparatus one is enabled to judge of a given area of water at different times of the day, states of the tide, from various depths, in fact of the planktonic variations as regards depth, temperature, density, wind, tide, etc.

The method which I employ is that of the centrifuge, an apparatus which consists of a series of geared wheels driven by hand or belt, and so arranged as to cause an upright shaft to revolve to a speed of 8,000 revolutions per minute, corresponding to 50 revolutions per minute of the crank or pulley wheel. To this upright shaft is fastened an attachment by means of which two funnel-shaped receptacles of 1 litre capacity each may be secured and made to revolve with the shaft. The main portion of each of these receptacles is constructed of spun copper, tinned. To this is attached the stem of the funnel consisting of a heavy annealed glass tube of 15 mm. in outside diameter with a central bore of 2½ to 5 mm. These glasses are held in place and protected by a cover, such as is employed in mounting a water-gauge.

The receptacles having been filled with the water to be examined, are caused to revolve for one or two minutes, when the entire contents of suspended matter in the water is thrown down to the bottom of the tube, from which the volume may be read off by means of the



graduated scale on the outside of the tube. The plankton thus expeditiously secured can be transferred quickly to a vial or other receptacle, to be weighed or otherwise examined at leisure.

The apparatus is simple and efficient, covering, I think, some of the faults in the Hensen method, as pointed out by Haeckel, at any rate supplementing the counting method by one which makes it possible to secure a far greater number of estimations in a given time. It is free from many sources of error connected with the use of a net, and for the practical purposes of oyster and fish culture enables the scientist in charge to ascertain the diurnal variations of any given area of water, from planktonic standards previously established under the most favorable conditions. I have chosen the name planktonokrit for this apparatus, and I am confident that it will facilitate in many ways the solution of the œcological problems which confront the student of aquatic organisms, and at any rate free him, to a certain extent, from " the Danaides task " of counting the individuals.

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